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DIVIDENDS FROM WOOD RESEARCH

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Recent Publications

January-June 1986

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instructions and explanation

"Dividends From Wood Research" is a semiannual listing of recent publications resulting from wood utilization research at the Forest Products Laboratory (FPL). These publications are produced to encourage and facilitate application of Forest Service research. This issue lists publications received from the printer by the FPL Publications Section between January 1, 1986, and June 30, 1986.

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list of categories

Publications are listed in this brochure within the following general categories:

Anatomy and identification
Biotechnology
Chemistry and energy
Composite products and adhesives
Fire
General
Material properties and construction
Mycology
Packaging
Preservation and protection
Processing of lumber
Pulp and paper
Timber requirements and economics.

anatomy and identification

Functional and Ecological Wood Anatomy

In: Baas, Pieter; Miller, Regis B., eds. Proceedings of the Martin H. Zimmermann Memorial Symposium; 1985 August 12; Gainesville, FL. 118 p. (Available from International Association of Wood Anatomists, Office of the Executive Secretary, Institute of Systematic Botany, Heidelberglaan 2, 3584 CS Utrecht, The Netherlands; \$15.)

This book brings together nine contributions on the related subjects of functional and ecological wood anatomy, and reports and discusses original results which considerably extend our understanding of limiting factors in xylem sap transport, ecological strategies in xylem evolution, and phylogenetic constraints. In addition the literature on these subjects of the last decade(s) is comprehensively reviewed. A dedication to and short biography of the late Martin H. Zimmermann, whose pioneering work in functional wood anatomy has been such an important influence, precedes the research papers.

biotechnology

1. Biopulping, Biobleaching and Treatment of Kraft Bleaching Effluents with White-rot Fungi

Eriksson, K.-E.; Kirk, T. K.
In: Cooney, Charles L.; Humphrey, Arthur E., eds. The Principles of Biotechnology: Engineering Considerations. In: Moo-Young, Murray, ed. Comprehensive Biotechnology: The Principles, Applications and Regulations of Biotechnology in Industry, Agriculture and Medicine. New York: Pergamon Press; 1985: 271-294.

The authors discuss properties of wood-rotting fungi, lignin degradation by these fungi, and biobleaching of kraft pulp. Treatment of kraft bleach plant effluents is also discussed.

2. Effects of Culture Conditions on the Fermentation of Xylose to Ethanol by *Candida shehatae*

Jeffries, Thomas W.
Biotechnol. Bioeng. Symp. 15; 1985: 149-166.

This research examined four factors on the fermentation of xylose by *Candida shehatae*, and the following conclusions were reached: (1) A minimal medium is effective for producing ethanol. (2) Peptone and casamino acids stimulate ethanol production. (3) Aeration is important in obtaining good ethanol production rates and yields. (4) The maximal rate of ethanol production is attained around pH 3.2-3.4. Under the best conditions employed, *C. shehatae* ATCC 22984 produced up to 4 percent (w/v) ethanol from 20 percent xylose in 4 days. With 9 percent xylose, ethanol yields approximating 0.4 g/g xylose were obtained.

3. Production of Multiple Ligninases by *Phanerochaete chrysosporium*: Effect of Selected Growth Conditions and Use of a Mutant Strain

Kirk, T. Kent; Croan, Suki; Tien, Ming; Murtagh, Karen E.; Farrell, Roberta Lee
Enzyme Microb. Technol. 8: 27-32; 1986.

Two methods are described for increasing the production of ligninase by cultures of *Phanerochaete chrysosporium* grown in a nitrogen-limiting medium. The first method involves addition of veratryl alcohol (0.4 mM) and excess trace metals to stationary flask cultures. The second method entails scale-up using a disc fermenter with a mutant strain which adheres well to the plastic discs, in contrast to the wild type, and which in addition produces high titres of ligninase. The ligninases produced by the mutant and wild-type strains were analyzed by native-gel electrophoresis and visualized by silver staining and Western blot analysis. They were also compared by V8 protease digestion analyses. Results indicate a high degree of homology between the ligninases within each strain in addition to homology between the corresponding ligninases of the two stains.

4. Lignin Degrading Activity of *Phanerochaete chrysosporium* Burds.: Comparison of Cellulase-negative and Other Strains

Kirk, T. Kent; Tien, Ming; Johnsrud, Susanna C.; Eriksson, Karl-Erik
Enzyme Microb. Technol. 8: 75-80; 1986.

This study compared selected strains of *Phanerochaete chrysosporium* on the basis of their total ligninolytic activity ([¹⁴C] lignin T 14CO₂), and production of lignin-depolymerizing enzymes, ligninases. The seven strains included three wild-type isolates (ME-446, K-3 and BKM-F-1767), three cellulase-negative (Cel⁻) mutants (3113, 13132-176 and 85118-22, all derived from K-3), and one mutant strain selected for rapid decolorization of an industrial byproduct lignin (SC26, derived from BKM-F-1767). Results reveal wide variation in lignin-degrading capacity of *P. chrysosporium* and show that Cel⁻ mutants can be unaffected in lignin-degrading ability.

5. Steady-State and Transient-State Kinetic Studies on the Oxidation of 3,4-Dimethoxybenzyl Alcohol Catalyzed by the Ligninase of *Phanerochaete chrysosporium* Burds

Tien, Ming; Kirk, T. Kent; Bull, Christopher; Fee, James A.
J. Biol. Chem. 261(4): 1687-1693; 1986.

The paper describes a kinetic study of the mechanism of a lignin-degrading enzyme. Rapid-scan spectroscopic techniques were employed, with veratryl alcohol as enzyme substrate. Results show that this substrate is oxidized by two electrons, and provide evidence that ligninase is a peroxidase.

chemistry and energy

6. Kinetic Modeling of Hardwood Prehydrolysis. Part III. Water and Dilute Acetic Acid Prehydrolysis of Southern Red Oak

Conner, Anthony H.; Lorenz, Linda F.
Wood Fiber Sci. 18(2): 248-263; 1986.

The data presented in this report indicate that, at higher temperatures, water or dilute acetic acid prehydrolysis gives yields comparable to those for dilute sulfuric acid prehydrolysis at 170°C recently reported in the literature. Preliminary results with lignin isolated from the water and acetic acid prehydrolysis residues confirm recent reports that lignins of this type are useful as phenol substitutes in phenol-formaldehyde adhesives.

7. Kinetic Model for the Dilute Sulfuric Acid Saccharification of Lignocellulose

Conner, Anthony H.; Wood, Barry F.; Hill, Charles G., Jr.; Harris, John F.
J. Wood Chem. Technol. 5(4): 461-489; 1985.

Despite continuing interest in various processes for producing ethanol or other chemicals from agricultural and wood residues, little attention has been given to improving the kinetic modeling of dilute acid saccharification of cellulosics, a key step in many of these processes. A new model for cellulose saccharification is proposed. It incorporates the effect of the neutralizing capacity of the substrate, the presence of readily hydrolyzable cellulose, and the reversion reactions of glucose. Although general in nature, the model was developed specifically for application to the dilute sulfuric acid saccharification of prehydrolyzed wood lignocellulose. A computer program to simulate the new model under various reaction conditions was prepared. This program reasonably predicts yields of fermentable (monomeric) sugar, reducing sugar, reversion material, remaining cellulose, as well as glucose lost by dehydration, all as a function of acid concentration, temperature, and reaction time.

8. Comparison of Alternatives for the Fermentation of Pentoses to Ethanol by Yeasts

Jeffries, T. W.
In: Lowenstein, Michael Z., ed. Energy Applications of Biomass: Proceedings of the National Meeting on Biomass R&D for Energy Applications; 1984 October 1-3; Arlington, VA. New York, NY: Elsevier Applied Science Publishers; 1985: 231-252.

In the kraft pulping process, lignin and hemicellulose are extracted under alkaline conditions and then burned to recover chemicals and energy. In some instances, the lignin is recovered for other applications. The hemicellulose is largely degraded to organic acids prior to combustion and has no current commercial value. Other technologies are being developed that will enable the efficient fractionation of lignocellulose into pulp-grade cellulose, useful lignin derivatives, and useful hemicellulosic sugars including xylose.

The objective of the research described in this paper is to improve our knowledge of pentose metabolism in yeasts and to thereby provide the means for more efficient utilization of xylose.

Chemical Effects of Mixed Hardwood Furnish on Panel Properties

Johns, William E.; Rammon, Richard M.; Youngquist, John In: Maloney, Thomas M., ed. Proceedings of the 19th Washington State University International Particleboard/Composite Materials Symposium; 1985 March 26-28; Pullman, WA. Pullman, WA: Washington State University; 1985: 363-377. (Available from William E. Johns, Washington State University, Pullman, WA 99164. No charge.)

Wood from five species of hardwoods (aspen, green ash, paper birch, red maple, and northern red oak) was characterized for pH, buffering potential, bound and soluble acids, water and alcohol-benzene soluble extractive. In addition, all acidity tests were performed on mixtures of these five species. Flakeboard panels were produced from matched wood samples and the correlations between chemical qualities of the wood and mechanical properties of the panels were developed.

Chemical tests showed that wood mixtures do not follow ideal mixture behavior. The degree of nonideality depended on the individual species involved.

9. Quantitative ^{13}C NMR Characterization of Lignin. I. A Methodology for High Precision

Landucci, Lawrence L.
Holzforschung. 39(6): 355-359; 1985.

It was established that various peak ratios in ^{13}C nuclear magnetic resonance (NMR) spectra of an acetylated milled wood lignin can be measured with a precision within 3 percent for large samples (700 mg) in 6-hour runs, and a precision within 10 percent for 1-hour runs. For small samples (70 mg), a precision of 10 percent required 22-hour runs. This was accomplished by using spectral widths (SW) about three times larger than the minimum required for the lignin resonances, and 45° tip angles rather than more typical SW and 90° tip angles, and by the use of an improved integration methodology.

10. Adducts of Anthrahydroquinone and Anthranol With Lignin Model Quinone Methides. 9,10- ^{13}C Labelled Anthranol-Lignin Adducts; Examination of Adduct Formation and Stereochemistry in the Polymer

Ralph, John; Landucci, Lawrence L.
J. Wood Chem. Technol. 6(1): 73-88; 1986.

Threo and *erythro* isomers of 3-acetoxy-1-(4-acetoxy-3-methoxyphenyl)-1-(9,10-dihydro-10-hydroxy-9-oxoanthracen-10-yl)-2-(2-methoxyphenoxy)-propane 8 have been synthesized. These compounds are appropriate model compounds for adducts between anthranol (9-hydroxyanthracene) and quinone methides of b-aryl ether units in the lignin polymer. Adducts of this type are believed to result from side reactions during the anthraquinone-accelerated pulping of wood and may contribute to extensive losses of anthraquinone from the pulping system. The ^{13}C NMR chemical shifts of C-10 in the *threo* and *erythro* isomers of 8 are 44.1 and 47.5 ppm relative to tetramethylsilane. Peaks with corresponding chemical shifts appeared in a spectrum of an acetylated adduct prepared from lignin and 9,10- ^{13}C labelled anthranol. As in model systems the *threo* isomer predominated.

On the Palladium-on-Charcoal Disproportionation of Rosin

Song, Zhan-Qian; Zavarin, Eugene; Zinkel, Duane F.
J. Wood Chem. Technol. 5(4): 535-542; 1985. (Available from Eugene Zavarin, Forest Products Laboratory, University of California, 1301 S. 46th Street, Richmond, CA 94804. No charge.)

Changes in the composition of gum rosin during disproportionation in the presence of 5 percent palladium-on-charcoal have been determined by gas chromatography. The principal reaction product was dehydroabietic acid. The exocyclic vinyl group of the pimaric/isopimaric-type resin acids was hydrogenated completely. Only a small amount of dihydroabietic acids was formed. Eight dihydro resin acids were identified. No tetrahydro resin acids were observed.

11. Important Factors Involved in Storing Bark and Bark-Free, Whole-Log, and Whole-Tree Chips

Springer, E. L.
In: Robertson, Doris, coord. The 7th International FPRS Industrial Wood Energy Forum '83, vol. 1; 1983 September 19-21; Nashville, TN. Proceedings 47337. Madison, WI: Forest Prod. Res. Soc.; 1985: 189-202.

The important factors influencing rates of weight loss of wood, bark, and foliage during outdoor pile storage can be listed as follows: type of material, wood species, season cut, age when cut, season stored, pile size and shape, and particle size. The effect of each variable on weight loss has been elucidated using data from the literature and from an unpublished study. General guidelines for minimizing losses during storage are discussed. In addition to weight losses from microbial attack, the possibility of losses due to spontaneous ignition must also be considered. In any situation where moist lignocellulosic materials are stored, some weight loss is inevitable; the objective is to minimize this loss and avoid the catastrophic losses resulting from spontaneous combustion.

12. Prehydrolysis of Hardwoods with Dilute Sulfuric Acid

Springer, Edward L.
Ind. Eng. Chem. Prod. Res. Dev. 24: 614-623; 1985.

The effects of temperature, time, acid concentration, wood species, liquor-to-wood ratio, particle size, and drying on hemicellulose hydrolysis and sugar yields during hardwood prehydrolysis were investigated. A full factorial design was used to study the effects of liquor-to-wood ratio, particle size, and drying on prehydrolysis of southern red oak. Liquor-to-wood ratio and drying had no significant effects. Wood particle size affected the rate of hydrolysis because of poor impregnation of large particles with acid. The remaining variables were studied by using dried wood, thin, easily impregnated disks, and a high liquor-to-wood ratio (3.9:1). A factorial design was used to study the effects of temperature and acid concentration on the maximum quantity of xylose and its oligomers found in solution during prehydrolysis of red oak. Maximum potential xylose increased with increasing temperature and acid concentration; 87 percent was obtained at 190°C and 0.80 percent H₂SO₄. Wood species had little effect upon results.

13. GLC Determination of the Resin Acid Composition in Rosins and Oleoresins: State of the Art

Zinkel, Duane F.; Han, James S.
Naval Stores Review. 96(2): 14-19; 1986.

Gas chromatographic methods using packed or capillary columns are reviewed for the analysis of resin acids in rosins and oleoresins. In general, polyesters are the preferable liquid phases (EGSS-X for packed columns and BDS for capillary columns) for the common resin acids found in rosin. However, oxygenated resin acids often require a second gas chromatographic determination using a nonpolar methyl silicone stationary phase. The implications of sampling, ester preparation, columns and instrument parameters on the analysis of resin acids are discussed.

EXCHANGE Record

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composite products and adhesives

14. Mechanical Property Ratios: A Measure of Flake Alignment

Geimer, Robert L.
USDA Forest Serv. Res. Pap. FPL 468; 1986.

This report expands on equations that predict certain board properties and presents formats that can be used by both researchers and manufacturers.

15. Properties of Structural Flakeboard Manufactured from 7-Year-Old Intensively Cultured Poplar, Tamarack, and Pine

Geimer, Robert L.
Forest Prod. J. 36(4): 42-46; 1986.

The objective of this study was to determine the effect of species and clonal variation on structural flakeboard properties, and to compare the results to those obtained previously when 6-year-old material was used.

Structural flakeboard made from 7-year-old intensively cultured tamarack and jack pine was less durable and had poorer mechanical properties than either of two poplar hybrid clones grown under the same conditions. Boards made with 7-year old *Populus* material had reduced bending but increased internal bond properties when compared to boards made with similar 6-year-old material. The same strength differences attributed to clonal variation in younger poplars were also found in the boards made from the 7-year-old material.

Implications of a Design Approach for Mixed Hardwood Structural Flakeboard

Hoover, W. L.; Hunt, M. O.; Lattanzi, R. C.; Maloney, T. M.; Youngquist, J. A.
In: Maloney, Thomas M., ed. Proceedings of the 19th Washington State University International Particleboard/Composite Materials Symposium; 1985 March 26-28; Pullman, WA. Pullman, WA: Washington State University; 1985: 381-404. (Available from William Hoover, Department of Forestry and Natural Resources, Purdue University, West Lafayette, IN 47907. No charge.)

A technique for designing structural oriented strand panels composed of mixtures of hardwood species is presented. In addition, the role of product design and processing models in the development and implementation of competitive strategies in the structural panel industry is discussed.

16. Optimization of Composite Wood Structural Components: Processing and Design Choices

Laufenberg, Theodore L.
In: Maloney, Thomas M., ed. Proceedings of the 19th Washington State University International Particleboard/Composite Materials Symposium; 1985 March 26-28; Pullman, WA. Pullman, WA: Washington State University; 1985: 77-94.

Decreasing size and quality of the world's forest resources are responsible for interest in producing composite wood structural components. Process and design optimization methods are offered in this paper. Processing concepts for wood composite structural products are reviewed to illustrate manufacturing boundaries and areas of high potential. Structural optimization principles are introduced to provide an overview of design requirements for various structural elements. An approach to the optimal design of a simple joist is presented. The approach allows the optimization for a variety of possible limit states using minimum weight as the objective function. Three aligned flake materials are used in examples of (1) minimum weight of the 2 by 10 joists and (2) maximum stiffness-to-weight ratio for a uniformly loaded long span. Results from the optimizations show how beam geometry affects efficiency.

17. Using Gamma Radiation to Measure Density Gradients in Reconstituted Wood Products

Laufenberg, Theodore L.
Forest Prod. J. 36(2): 59-62; 1986.

The primary objective of this work was to assemble and test a gamma radiation-based density gradient measurement system to replace the accepted gravimetric method of obtaining density gradients from reconstituted products. Modeled after the radiation based system described by Ranta and May, the gamma radiation technique provides a nondestructive means of measuring density gradients for researchers and manufacturers of wood composite materials.

A survey of methods for determining density gradients is presented, followed by a discussion of the theory and equipment required when using a gamma radiation source. Tests of the system are detailed to determine the mass attenuation coefficients needed to obtain densities of reconstituted products, and to investigate the system inaccuracies caused by the resin and moisture in these products.

18. Fluorescence Microscopy of Hardboards

Murmanis, Lidija; Myers, Gary C.; Youngquist, John A.
Wood Fiber Sci. 18(2): 212-219; 1986.

The authors developed a microscopic technique and used it to explore the internal structure and resin distribution in hardboards. The technique will enable us better to understand the behavior of hardboards in use. Glycol methacrylate (JB-4 embedding medium) proved to be satisfactory for preparing 10- to 15-mm sections of hardboards with a steel knife on a sliding microtome. This thickness of sample, when viewed in transmitted near-ultraviolet light, allowed a clear visualization of hardboard internal structure and resin distribution through the board thickness. We examined wet-formed and dry-formed hardboard samples. Wet-formed high-density and medium-density boards usually showed fibers consolidated into a compact structure and a uniform resin distribution. Dry-formed high-density boards had a compact structure and medium-density boards a less compact structure; both characteristically showed uneven resin distribution.

19. Feasibility of Manufacturing Hardboard from Short-Rotation Intensively Cultured *Populus*

Myers, Gary C.; Crist, John B.
Forest Prod. J. 36(1): 37-44; 1986.

A hybrid poplar, *Populus "Tristis No. 1,"* grown under short-rotation intensive culture, was investigated as a possible raw material source for the manufacture of hardboard. All aboveground material was chipped, and a portion of the chips was upgraded with vacuum airlift segregation to remove some fines and bark. Debarked aspen stemwood was used as a control. All chips were fiberized in a small pressurized single-disk refiner, and medium- and high-density hardboards were made from the pulps by both the wet- and dry-forming processes. Two resin contents were used in each type of hardboard manufactured. Hardboards were evaluated for strength properties and dimension change, and test results were analyzed statistically. Results indicate that intensively cultured *Populus* raw material is suitable for manufacturing hardboards.

20. Strength and Durability of Alkylresorcinolic Adhesives from Estonian Oil Shale Kerogen

River, Bryan H.
Forest Prod. J. 36(4): 25-34; 1986.

Estonian scientists have developed adhesives from the kerogen in Estonian oil shale. The adhesives, based on a series of alkylresorcinols extracted from the kerogen, have distinct economic and environmental advantages over resorcinol-based resins for wood laminating. In this study we evaluated their unaged shear strength and wood failure in bonded hard maple specimens and the change in these properties after elevated temperature aging in constant wet and dry exposures. Based on these studies, the adhesives are quite comparable in strength, although small but statistically significant differences are detected in both unaged and aged specimens. They should have comparable service lives in constant service conditions. The major difference between the adhesives is the low wood failure in specimens bonded with alkylresorcinolic adhesives. Low wood failure suggests the alkylresorcinolic adhesives may be sensitive to cyclic swelling and shrinking. Increasing adhesive failure may not be a problem with softwood lumber or with different bonding conditions, but further exploration will be required before alkylresorcinolic adhesives could be accepted as equal substitutes for resorcinolic adhesives in structural laminates for exterior use.

21. Property Enhancement of Particleboards Made From Chemically Modified Chips

Rowell, Roger M.

In: Lawniczak, M., ed. Wood Modification: Proceedings of the Polish Academy of Science Meeting; 1985 March; Posnan, Poland. Posnan, Poland: Polish Academy of Science; 1985: 358-366.

Chemical modification of wood cell wall polymers changes the basic properties of the wood. In solid wood, reacting various hardwoods and softwoods with epoxides, isocyanates, and anhydrides improves dimensional stability and resistance to attack by fungi, termites, and marine organisms. With solid wood, concerns arose with reagent penetration and the cost of and damage done by drying to very low moisture contents required for chemical modification. With the growing markets for reconstituted wood products, the technology developed for solid wood was applied to these products. Wood chips reacted with either butylene oxide or acetic anhydride before board production showed greatly improved dimensional stability to both liquid water and water vapor. Particleboards made from acetylated chips also showed greatly improved resistance to tunneling bacteria and brown- and soft-rot fungi.

22. Dimensional Stabilization of Flakeboard by Chemical Modification

Rowell, R. M.; Tillman, A.-M.; Zhengtian, Liu
Wood Sci. Technol. 20: 83-95; 1986.

Southern pine, aspen, and Douglas-fir flakes were reacted with either butylene oxide/triethylamine or acetic anhydride for various reaction times to give levels of bonded chemicals up to 25 weight percent gain. Flakes modified to 20 weight percent gain with butylene oxide gave a flakeboard which absorbed 25 percent less water and had reduced thickness swelling up to 50 percent as compared to an untreated flakeboard. With acetic anhydride modification, water absorption was 50 percent less and thickness swelling was reduced 85 percent. There was a 60 percent reduction in thickness swelling in flakeboard made from butylene oxide-modified flakes and 85 percent reduction from acetic anhydride-modified flakes when the boards were subjected to 90 percent relative humidity over a period of 20 days. The mechanism of effectiveness to reduce moisture uptake and thickness swelling is based on chemical bulking of, and a reduction in the hydrophilic nature of the cell wall polymers.

23. Fiber-Reinforced Wood Composites

Rowlands, R. E.; Van Deweghe, R. P.; Laufenberg, T. L.; Krueger, G. P.
Wood Fiber Sci. 18(1): 39-57; 1986.

The technical feasibility of producing internally reinforced laminated wood is evaluated experimentally. Numerous fiber reinforcements and adhesives are assessed, and effects of several processing and environmental parameters are included. Results demonstrate the increased strength and stiffness to be achieved under both tension and flexure by adding fiber reinforcement. Glass reinforcement is particularly suitable.

Warping of Laminated Wood Panels

Suchsland, Otto; McNatt, J. D.
East Lansing, MI: Michigan State University, Department of Forestry; 1985. 120 p.
(Available from NTIS, 5285 Port Royal Road, Springfield, VA 22161. Accession number PB86-212701/XAB; \$5.95 microfiche, \$16.95 hard copy.)

This study examines wood laminated panels as they are used in the furniture, fixture, construction, and door industries. Most of these panels are cross-laminated and use either solid or composite elements. The objectives were (1) to determine to what extent the warping of laminated panels can be described by a mathematical model as developed in the following section, (2) to treat warping of laminated panels as a result of the natural variability of wood by using statistical concepts and to gage the extent of such "natural warping" tendencies, and (3) to attempt the development of some general relationships between raw material, manufacturing, and dimensional variables on one hand and warping on the other.

Dimensional Stability and Biological Resistance of Particleboard Made From Acetylated Pine Wood Chips

Tillman, Anne-Marie; Simonson, Rune; Rowell, Roger M.

In: Lawniczak, M., ed. Wood Modification: Proceedings of the Polish Academy of Science Meeting; 1985 March; Posnan, Poland. Posnan, Poland: Polish Academy of Science; 1985: 436-446. (Available from Information Services Division, Kurt F. Wendt Library, College of Engineering, University of Wisconsin-Madison, 215 North Randall Avenue, Madison, WI 53706; \$5.)

Wood is a preferred material for many applications. As high quality, full size timber is becoming more scarce reconstituted wood products, e.g. particleboards, are finding a growing market. All wood products have the disadvantages, among others, of dimensional instability and susceptibility to biological degradation, which, however, can be controlled by means of chemical modification of the wood constituents.

In a preliminary study wood flakes were made to react with liquid acetic anhydride diluted with xylene, and made into flakeboards. The purpose of the present study was to perform the acetylation with acetic anhydride vapor, which eliminated the organic cosolvent used in the earlier study, and greatly simplified the recovery of excess chemicals.

24. Evaluation of a Method for Testing Adhesive-Preservative Compatibility

Winandy, Jerrold E.; River, Bryan H.
Forest Prod. J. 36(1): 27-32; 1986.

The current method for testing the compatibility of adhesive-preservative systems used in glulam timbers has not recently been correlated with actual performance. The historically used two-cycle soak-dry delamination method is compared here to a proposed multiple-cycle soak-dry method. To evaluate these, penta-treated and CCA-treated southern pine boards were bonded with phenol-resorcinol at room temperature to represent compatible and incompatible model systems, respectively. The amount of deep wood failure measured with the new method shows great sensitivity to differences in system compatibility. Deep wood failure of the two adhesive-preservative systems differed only slightly before exposure to the new method, but this difference increased after one cycle and continued to increase gradually with increasing cycles. Shear strength measured with the new method was less sensitive to differences in adhesive-preservative compatibility, while delamination measured with the old method was far less sensitive.

New Approaches to Wood Bonding: A Base-Activated Lignin Adhesive System

Young, R. A.; Fujita, M.; River, B. H.
Wood Sci. Technol. 19: 363-381; 1985. (Available from Raymond A. Young, Department of Forestry, University of Wisconsin-Madison, 1630 Linden Drive, Madison, WI 53706.)

Current knowledge of wood surface characteristics and surface modification are briefly reviewed and the postulated effects of chemical activation are summarized. It was found that aqueous sodium hydroxide can effectively activate wood surfaces to give strong dry autohesive bonds, but only low wet strength was obtained. However, excellent dry and wet wood bond strengths, equivalent to phenol-formaldehyde bonded samples, were obtained when methylolated lignin was used in combination with 3 N sodium hydroxide activation. Several mechanisms of base activation are suggested, including enhanced wood surface contact and reactivity.

25. Dimensional Stability of Acetylated Aspen Flakeboard

Youngquist, John A.; Krzysik, Andrzej; Rowell, Roger M. *Wood Fiber Sci.* 18(1): 90-98; 1986.

This study was conducted to determine if thickness swelling of flakeboards, which is much greater than that of plywood or solid wood, can be improved by chemical modification of the constituent wood flakes prior to board manufacture. The chemical treatment involved acetylation of oven-dry aspen ring flakes with a 50/50 mixture of acetic anhydride and xylene. Thickness swell of treated and control samples was measured by either immersion in water for periods of up to 10 days or exposure to 90 percent relative humidity for periods of up to 20 days. Treated samples exhibited one-sixth to one-seventh the thickness swelling of controls for the water-soak test. Similar trends were observed for humidity exposure.

fire

26. Heat Release Rates from Wall Assemblies: Oxygen Consumption and Other Methods Compared

Brenden, John J.; Chamberlain, David L. *USDA Forest Serv. Res. Pap. FPL-RP-476*; 1986.

This report describes a cooperative effort among the National Forest Products Association (NFPA), Washington, DC; Forest Products Laboratory (FPL), Madison, WI; and the Center for Fire Research at the National Bureau of Standards (NBS), Gaithersburg, MD. The objectives were (1) to obtain additional information on the performance of fire-retardant-treated wood-based structural assemblies exposed to fire, (2) to extend methods of measuring heat release rate (HRR) in individual materials to full-scale structural assemblies, (3) to compare HRR obtained by the substitution, oxygen consumption, and weight of material/heat of combustion methods, and (4) to determine if HRR measurements can be incorporated into American Society for Testing and Materials (ASTM) Method E 119.

27. Variability of Smoke Particulate Concentrations in the NBS Smoke Chamber

LeVan, Susan L.; Brenden, John J. *Forest Prod. J.* 36(5): 29-35; 1986.

The authors studied small-scale smoke yield measurements of 9.5-mm-thick, three-ply Douglas-fir plywood in the Aminco-NBS smoke density chamber to determine smoke distribution patterns, and observed the variability of these measurements. These data are needed to calculate the parameters used in predicting large-scale smoke yield. Based on 66 test runs, the smoke particulate concentration exhibited little systematic change with position except near the chamber walls. The measurement of optical density, smoke particulate concentration, and specimen weight loss showed coefficients of variation of 14, 16.6, and 27.3 percent, respectively. The large amount of variation introduces large uncertainties into estimates of the parameters, thus making good predictions difficult to achieve. The inherent variability of wood samples, due to differences of grain direction, surface density, and thermal degradation, accounts for some of the observed variation, whereas variations of equipment and procedure account for the remainder. Because the specimens are inherently variable, any reduction of experimental variation in the future must depend on improving the measurement of weight loss and optical density.

28. Effectiveness of Fire-Retardant Treatments for Shingles After 10 Years of Outdoor Weathering

LeVan, Susan L.; Holmes, Carlton A. *USDA Forest Serv. Res. Pap. FPL 474*; 1986.

Some building codes require wood shingles to be fire-retardant treated. Because exterior fire-retardant treatments are subjected to weathering, treatment durability and leach resistance are critical for insuring adequate fire protection. The effectiveness of various fire-retardant treatments on wood after 0, 2, 5, and 10 years of outdoor exposure was examined.

A Class C burning-brand test (ASTM E 108) and a Schlyter flamespread test to evaluate effectiveness were used. Most shingle treatments evaluated were either pressure impregnated or coated at the Forest Products Laboratory; however, a commercial treatment was used as a control. After 10 years of exposure, most treatments passed the Class C burning-brand test, but lost considerable effectiveness in the Schlyter test method. The commercial treatment was the most effective after 10 years of weathering.

29. An Empirical Model for Predicting Performance of Fire-Resistive Coatings in Wood Construction

White, Robert H. *J. Test. Eval.* JTEVA. 14(2): 97-108; 1986.

We developed an empirical model for predicting the fire-resistance performance of fire-resistant-coated wood based on small nonload-bearing fire-resistance tests. The equations in the model provide estimates for the times to reach either a temperature rise of 139°C or a temperature of 288°C. Using these equations, various applications for fire-resistant coatings in wood construction were examined. Applications considered include thermal barriers, walls, floors, large timber members, and doors.

Predictions using the model compared favorably with the very limited experimental data available in the literature. Additional research is needed before use of fire-resistant coatings in wood construction can be realized.

general

Sitka Spruce and Western Hemlock Beach Logs in Southeast Alaska: Suitability for Lumber, Pulp, and Energy

Ernst, Susan; Plank, Marlin E.; Fahey, Donald J. *USDA Forest Serv. Res. Pap. PNW-352*; 1986. (Available from USDA, Forest Service, Pacific Northwest Research Station, 319 SW. Pine St., P.O. Box 3890, Portland, OR 97208.)

The suitability of western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) and Sitka spruce (*Picea sitchensis* (Bong.) Carr.) beach logs in southeast Alaska for lumber, pulp, and energy was determined. Logs were sawn at a cant mill in southeast Alaska and at a dimension mill in northern Washington. Volume and value recovery was compared among samples of live, recent dead, and older dead classes of logs. The live and recent dead samples produced about the same quantity and quality of lumber. The older dead sample produced less volume and lower quality lumber. There were no difficulties in pulping or gasification of the beach logs, but a higher salt content may cause problems with boiler corrosion and stack emissions.

30. Preliminary Evaluation of Electronic Measurements for Presorting Hem-Fir Dimension Lumber

Ward, James C.; James, William L.; Kozlik, Charles J. In: *Western Dry Kiln Clubs Proceedings, Joint Meeting; 1985 May 8-10; Corvallis, OR*. Corvallis, OR: Western Dry Kiln Clubs; 1985: 97-98.

A laboratory study was initiated to evaluate the accuracy of electronic techniques for use in the commercial presorting of green hem-fir dimension lumber. Seven different types of electronic instruments were tested on green sapwood, heartwood, and sinker heartwood in short-length board samples from western hemlock (*Tsuga heterophylla*) and white fir (*Abies concolor*). The electronic tests are divided into three groups: conductance tests, dielectric tests, and longitudinal stress-wave tests.

material properties and construction

31. The Influence of Moisture Content on the Flexural Properties of Douglas Fir Dimension Lumber

Aplin, E. Nicholas; Green, David W.; Evans, James W.; Barrett, J. David
USDA Forest Serv. Res. Pap. FPL 475; 1986.

Lumber of three grades (Select Structural, No. 2, No. 3) and three sizes (2 x 4, 2 x 6, 2 x 8) was tested on edge in third-point bending at moisture content levels of green, 20 percent, 15 percent, and 10 percent. Results indicate that current ASTM D 245-81 adjustments are valid for modulus of elasticity but not for modulus of rupture.

32. Lateral Load-Bearing Capacity of Nailed Joints Based on the Yield Theory: Theoretical Development

Aune, Petter; Patton-Mallory, Marcia
USDA Forest Serv. Res. Pap. FPL 469; 1986.

A European-based yield theory using a material science approach predicts the ultimate lateral load of nailed joints with different joint configurations. The original theory is presented here and extended to include steel-to-wood joints and joints with a layer of insulation (or gap) between joint members. Formulas provide ultimate load for wood-to-wood and steel-to-wood joints and joints with unequal wood strength. A final formula represents the relationship between the wood's embedding stress and deformation not on the traditional assumption of plasticity, but as a fourth-root curve.

33. Lateral Load-Bearing Capacity of Nailed Joints Based on the Yield Theory: Experimental Verification

Aune, Petter; Patton-Mallory, Marcia
USDA Forest Serv. Res. Pap. FPL 470; 1986.

The yield theory of joint loading provides a method to analyze nailed joints using a material science approach. The analysis requires a knowledge of two material properties, wood embedding strength and nail yield moment. The yield theory predicts the ultimate lateral load for bolted or nailed joints. The purpose of this study is to verify the yield theory experimentally for a limited number of nailed joints using wood species and joint geometries typical of construction in the United States. The yield theory is applied to a variety of nailed joint configurations. The strengths of 265 nailed joints subject to short-term loading are predicted on the basis of nail and wood properties and confirmed by experiments. The experimental tests validate application of the yield theory also to nailed joints whose members have dissimilar wood properties, to joints with steel center plates or with a gap caused by insulation between joint members. Finally, the stiffness and strength of two-member joints measured by American test method (ASTM) are compared to those of three-member joints measured by European test method.

34. Mechanical and Anatomical Properties in Individual Growth Rings of Plantation-Grown Eastern Cottonwood and Loblolly Pine

Bendtsen, B. A.; Senft, John
Wood Fiber Sci. 18(1): 23-38; 1986.

This study determined relationships between age and mechanical and anatomical properties, the average properties of juvenile and mature wood, the age of demarcation between juvenile and mature wood, and the projected proportions of juvenile and mature wood at various ages in plantation cottonwood and loblolly pine. It also compared projected properties of plantation trees with those published for trees from natural forests.

35. Duration of Load Research on Lumber at the U.S. Forest Products Laboratory

Gerhards, Charles C.
In: Proceedings of the International Workshop on Duration of Load in Lumber and Wood Products; 1985 September 12-13; [Vancouver, BC]. Vancouver, BC: Forintek Canada Corp.; 1986: 14-21.

The author summarizes the test program at the Forest Products Laboratory and lists the objectives for conducting duration of load research.

All of the objectives except for one item are associated with loading in the bending mode. That item includes tension and compression. Four different types of machines were developed and several samples of lumber were obtained to conduct the necessary studies. The experimental techniques are discussed in this document.

36. Effect of Loading Rate on Bending Strength of Douglas-fir 2 by 4's

Gerhards, C. C.; Link, C. L.
Forest Prod. J. 36(2): 63-66; 1986.

Select Structural (SS) and No. 2 Douglas-fir lumber specimens were tested at three different rates of loading to determine the rate-of-loading effect on bending strength of lumber and, through a damage accumulation model, the duration-of-load effect. Results show that average strength increases nearly linearly with the logarithm of loading rate. Results also show that rate of loading affects the total distribution of bending strength, contrary to claims in published reports. The rate-of-loading effect and, consequently, the duration-of-load effect appears to be greater for SS than for No. 2 lumber graded on the basis of size and location of knots and slope of grain. These results will be complemented by results from constant load tests currently underway.

37. Predicting the Effect of Moisture Content on the Flexural Properties of Southern Pine Dimension Lumber

Green, David W.; Link, Carol L.; DeBonis, A. Louis;
McLain, Thomas E.
Wood Fiber Sci. 18(1): 134-156; 1986.

Current procedures for adjusting lumber properties for changes in moisture content are based on trends observed with the mean properties. This study was initiated to develop analytical procedures for adjusting the flexural properties of 2-inch-thick southern pine dimension lumber applicable to all grades and sizes as well as all levels of the cumulative frequency distribution. Equations are derived for adjusting modulus of rupture (MOR), modulus of elasticity (MOE), moment capacity (RS), and flexural stiffness (EI) for changes in moisture content. The best of these equations are significantly more accurate than current procedures for adjusting strength properties (MOR and RS). Because MOE and EI are less affected by changes in moisture content, most of the equations, including the current American Society for Testing and Materials procedure, work well for these properties.

Influence of Lumber Property Correlations on Roof Truss Reliability

Hamon, D. C.; Woeste, F. E.; Green, D. W.
Trans. ASAE. 28(5): 1618-1625; 1985. (Available from Frank Woeste, Agricultural Engineering Department, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061. No charge.)

This study utilizes state-of-the-art information concerning roof truss f14 behavior to simulate the effect of strength property correlations on roof truss reliability. Computer models were developed to simulate the behavior of five common roof truss patterns. Monte Carlo simulation was used to calculate probabilities of failure for each truss pattern, and level of strength property correlation. The information reported herein may be useful to lumber property researchers, wood truss researchers and those responsible for developing improved design procedures for wood construction.

38. Effect of Transverse Moisture Content Gradients on the Longitudinal Propagation of Sound in Wood

James, William L.

USDA Forest Serv. Res. Pap. FPL 466; 1986.

The apparent longitudinal speed of sound in a relatively long, thin (length at least 10 times greatest lateral dimension) specimen of green wood begins to increase almost immediately as the specimen begins to dry, even though the average moisture content (MC) is only slightly reduced. Presumably this results from a distortion of the wave front by the drying MC gradients; apparently the faster surface wave is detected before the expected arrival of the core wave. This study was an attempt to characterize the effect of MC gradients on the propagation of sound, in order to improve the interpretation of changes in speed of sound as indicators of changes in MC of the wood. Methods were developed to probe the wave front at the bottom of small holes bored into the end of the specimen.

39. The Interaction of Electrode Design and Moisture Gradients in Dielectric Measurements on Wood

James, William L.

Wood Fiber Sci. 18(2): 264-275; 1986.

Measurement of dielectric properties (capacitance and equivalent parallel conductance) of specimens with various moisture gradients, using 20 different electrode designs, showed that no electrode design eliminated the effect of moisture gradients on the measured average dielectric properties. A parallel-plate electrode, with poles on opposite faces of the specimen, was influenced least by moisture gradients, but as applied to dielectric moisture meters, the improvement did not appear to warrant the inconvenience of making contact with both sides of the specimen. There was a weakly defined indication that a dielectric moisture meter using the capacitance principle and operating at about 10 kHz would be least affected by moisture gradients.

Microwave Measurement of the Complex Dielectric Tensor of Anisotropic Slab Materials

King, R. J.; Yen, Y. H.; James, W. L.

In: Scanning Technology for the Eighties: Proceedings of a Technology Awareness Seminar; 1984 November 15-16; [Vancouver, BC]. Vancouver, BC: Forintek Canada Corp.; 1985: 63-75. (Available from Information Services Division, Kurt F. Wendt Library, College of Engineering, University of Wisconsin-Madison, 215 North Randall Avenue, Madison, WI 53706; \$5.)

Linearly polarized electromagnetic wave incident on an anisotropic material suffers attenuation, phase change, and depolarization upon transmission through or reflection from the material. Here it is shown how the measured electrical properties of a wave transmitted through dimension lumber can be used to determine the complex dielectric tensor. The theory, which applies equally to other lossy and anisotropic materials such as man-made composites having 2×2 uniaxial tensor, is couched in terms of the measurable attenuation, phase change, and depolarization.

A microwave measurement system has been developed for measuring these parameters. Results are given for extensive experiments, conducted at 4.81 GHz on Douglas-fir, for moisture contents ranging from dry to complete saturation. The technique shows considerable promise as an accurate non-destructive diagnostic tool for evaluating the electrical, and hence the physical and mechanical properties of semi-transparent anisotropic materials.

40. Stochastic Model for Modulus of Elasticity of Lumber

Kline, D. E.; Woeste, F. E.; Bendtsen, B. A.

Wood Fiber Sci. 18(2): 228-238; 1986.

A model was developed for generating the lengthwise variability in modulus of elasticity (MOE) of lumber. A limited grade selection of southern pine visual and machine stress-rated (MSR) grades formed the basic data base. A second-order Markov model was used to generate serially correlated MOE's along 30-inch segments for a piece of lumber. Modulus of elasticity indexes were obtained by dividing each correlated MOE by the average MOE of the piece of lumber.

The MOE of each segment was obtained by multiplying the MOE indexes by a single random observation from a distribution of MOE. The distribution characteristics of the generated MOE values are preserved, and the first- and second-order lengthwise serial correlations are preserved.

41. Tensile Strength of AITC 302-24 Grade Tension Laminations

Marx, Catherine M.; Evans, James W.
Forest Prod. J. 36(1): 13-19; 1986.

Computer simulation models are the most promising method of predicting distributional properties for a large number of laminating combinations. Several computer models for predicting the strength and stiffness distributions of glulam timbers have already been developed; one such model was developed.

Accurate and reliable tensile strength distributional characteristics for laminating grades of lumber are needed to provide input into these models, and to provide a baseline for determining the acceptance of alternate tension lamination grades and products. The purpose of this study was to evaluate tensile strength distributional properties for the most important grade of laminating lumber in the United States, the current American Institute of Timber Construction (AITC) visually graded tension lamination grade called 302-24.

42. Surface and Subsurface Characteristics Related to Abrasive-Planing Conditions

Murmanis, Lidija; River, Bryan H.; Stewart, Harold A.
Wood Fiber Sci. 18(1): 107-117; 1986.

The goal of this study was to examine the quality of abrasively planed wood surfaces when variable grit sizes, feed speeds, and depths of cut are used. Our observations show that grit size and wood structure and density seem to have larger effects on the depth and type of damage than feed speed and depth of cut. Coarser grit sizes seem to cause greater damage than finer grit sizes.

Surface damage in Douglas-fir occurs at every grit size, feed rate, and depth of cut combination; the latewood shows more severe damage than the earlywood. Surface damage is more variable in hard maple and yellow-poplar than in Douglas-fir. This variability may be caused by different cell types present at the surface and the angle of intersection between the surface and the rays. Similar machining conditions do not always have similar effects on the surface quality even in the same wood species. Other factors, such as moisture content, between and within species density variations or belt conditions, might also contribute to the surface quality variability, but these were not explored.

43. Strength Validation and Fire Endurance of Glued-Laminated Timber Beams

Schaffer, Erwin L.; Marx, Catherine M.; Bender, Donald A.; Woeste, Frank E.
USDA Forest Serv. Res. Pap. FPL 467; 1986.

Reported here is a validation of model predictive capability using an independent set of glued-laminated beams especially fabricated for this purpose. The model consists of a Monte Carlo simulation of beam fabrication and strength estimation calibrated to the strength and fire endurance of previously reported glued-laminated beam test results.

44. Details for Durable Timber Structures

Soltis, Lawrence A.

In: Ma, S. Marshall, ed. Effects of Deterioration of Safety and Reliability of Structures. Proceedings of a session sponsored by the Structural Division of the American Society of Civil Engineers in conjunction with the ASCE Convention; 1986 April 10; Seattle, WA. New York: American Society of Civil Engineers; 1986: 12-21.

Some timber structures last for centuries, whereas others develop problems shortly after construction, often because of moisture problems. This paper discusses the basic principles of moisture-related problems, i.e. shrink/swell and decay problems. It gives examples of good and bad design details which should be considered when designing a structure.

45. Instrumentation for Measuring Moisture in Building Envelopes

TenWolde, A.; Courville, G. E.

In: ASHRAE Transactions 1985, vol. 91, part 2: Proceedings of ASHRAE Annual Meeting; [1985]; Honolulu, Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.; 1985: 1101-1115.

This paper discusses moisture measurement instrumentation available or required for building research, together with some recent developments. The paper focuses on measurement of in situ moisture content and humidity in buildings and building components. Electric resistance measurements have been most often used for this purpose. This method has the advantage of being relatively cheap, but many interfering factors limit the accuracy obtainable and the method is inherently intrusive. An alternative method, using capacitance measurements, is nonintrusive, provided that the area of interest is close to the surface. It is potentially less sensitive to interference from some extraneous factors, but at present it is difficult to use quantitatively. Both electrical methods face major problems because they assume a homogeneous distribution of moisture and because conducting material layers can greatly interfere. A promising technique is nuclear magnetic resonance, but currently it does not yield reliable quantitative results and involves complex and expensive apparatus.

46. Floor Loads for Reliability Analysis of Lumber Properties Data

Thurmond, Michael B.; Woeste, Frank E.; Green, David W. Wood Fiber Sci. 18(1): 187-207; 1986.

Utilizing load information reported in previous studies, distributions of maximum lifetime floor live loads in a form suitable for use in reliability analyses of lumber properties data were developed. An extreme value type I distribution is chosen as best representing normalized maximum lifetime floor live loads.

Examples are given in which contrasting lumber data sets are compared using the calculated load distributions and assuming that each set must provide equal reliability, or equal safety, in the final design. A factor, k, resulting from the reliability analysis is shown to be a logical adjustment parameter for use in engineering design codes.

Combining these results with those of an earlier paper, the selection of load distributions for use in reliability analysis of lumber properties data is discussed.

47. Load Distribution Among Bolts Parallel to Load

Wilkinson, Thomas Lee

J. Struct. Eng. 112(4): 835-852; 1986.

Measured distributions of load among two, three, five, or seven bolts in a row parallel to the direction of the applied load are presented for joints of various width Douglas-fir main members and two widths of steel splice plates. An analytical method of predicting the load distribution is also presented. The results show that each row has a unique load distribution dependent upon the variation in load-slip curves and fabrication effects. The analytical method is shown to predict the distribution as long as sufficient knowledge of the individual fastener load-slip relations is available. Results indicate that present design procedures for rows of bolts are not conservative.

48. Strength and Stiffness of Light-Frame Sloped Trusses

Wolfe, Ronald W.; Percival, Donald H.; Moody, Russell C. USDA Forest Serv. Res. Pap. FPL 471; 1986.

Bending tests conducted on 42 wood trusses provided information on the effects of truss slope and lumber modulus of elasticity (MOE) on truss strength and stiffness. Two 28-foot-span Fink truss configurations with slopes of 3/12 and 6/12 were tested. Component lumber was all No. 2 grade southern pine separated into low, medium, and high MOE categories. All trusses exhibited linear load vs. deformation behavior up to and beyond twice their design load range. Variations in load carrying capacity were small within a slope/stiffness category, and lumber stiffness appeared to be closely correlated with load capacity, failure mode, and truss stiffness. Information in this report is an important first step toward formulating improved structural analysis procedures for roof systems.

mycology

49. Determination of Hydrogen Peroxide Production in *Coriolus versicolor* and *Poria placenta* During Wood Degradation

Highley, Terry L.; Murmanis, Lidija L. Mater. Org. 20(4):241-252; 1985.

The purpose of this study was to use the DAB reaction to cytochemically identify and localize H_2O_2 in the brown-rot fungus, *P. placenta*, and the white-rot fungus, *Coriolus versicolor*, during degradation of wood. This information should provide further insight into the role of H_2O_2 in wood degradation by brown-rot and white-rot fungi.

Redisposition of *Radulum concentricum* (*Aphyllophorales, Corticiaceae*)

Kropp, Bradley, R.; Nakasone, Karen K.

Mycotaxon. 24: 423-429; 1985. (Available from Information Services Division, Kurt F. Wendt Library, College of Engineering, University of Wisconsin-Madison, 215 North Randall Avenue, Madison, WI 53706; \$5.)

Radulum concentricum, known from British Columbia, Washington, Oregon, California, and Montana, is described and illustrated. The new combination *Phlebia concentrica* is proposed.

50. Electron-Dense Particles in Wood Decayed by *Ganoderma applanatum*

Murmanis, L.; Palmer, J. G.; Highley, T. L. Wood Sci. Technol. 19: 313-321; 1985.

Hemlock sawdust samples degraded by *Ganoderma applanatum* showed no electron-dense particles either in hyphae or in wood cell walls after aldehyde/ OsO_4 fixation. After $KMnO_4$ fixation at early stage of attack, particles were in hyphae, hyphal sheath and wood cell walls. In samples prepared by a cytochemical technique which localizes cellulase activity at the ultrastructural level, particles were in hyphae, hyphal sheath and wood cell walls. The smallest diameter range of the particles lay between 3 and 7 nm which corresponds to the size of cellulases. Larger diameter particles were present which are probably aggregates of the smaller units. We believe that particles present in hyphal cytoplasm and hyphal sheath are cellulolytic enzymes. Whether particles present in attacked wood cell walls are enzymes or degradation products cannot be determined by this study. Nevertheless, the particles reveal the decay pattern in wood by the white-rot fungus *G. applanatum*.

The Effects of Supraoptimal Temperatures upon North American Brown-Rot Fungi in Pure Culture

Palmer, John G.; Payne, Ruth G.

Can. J. For. Res. 16: 169-176; 1985. (Available from John G. Palmer, Department of Biology, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061. No charge.)

Ninety-one North American brown-rot fungi were exposed in agar culture to four high temperatures for 16 days. Isolates originated from basidiospores, sporophore tissue, or decaying wood. One or more isolates of 58 species grew at 35°C, of 20 species at 41°C, and of 4 species at 46°C; none grew at 52°C. Similar inter- and intra-specific variations occurred during recoveries in the absence of growth. Some isolates of two species of *Antrodia* recovered after exposure to 52°C. The possibility that a brown rotter might be active, alive but inactive, or neither within a wood substrate can be inferred by comparison of ratings derived by mathematical formulae applied to species represented by four or more isolates. Species that destroy wood products made up 73 percent of those likely to grow at these higher temperatures and 81 percent of those most likely to recover from exposure to supramaximal temperatures based upon these ratings. Only 2 of the 12 fungi least capable of growth and recovery at high temperatures were associated with forest products. Temperature ratings for two fungi that had been isolated by another worker from western pine slash coincided with the upper and lower portions in which they occurred. However, field data were insufficient for a satisfactory comparison of sapwood and heartwood rotters.

packaging

51. New Rapid Method for Determining Edgewise Compressive Strength of Corrugated Fiberboard

Koning, John W., Jr.

Tappi J. 69(1): 74-76; 1986.

The objective of this study was to determine if corrugated fiberboard specimens that had been necked down with a common router would yield acceptable edgewise compressive strength values. Tests were conducted on specimens prepared using a circular saw and router, and the results were compared with those obtained on specimens prepared according to TAPPI Test Method T 811. The materials used in the tests included singlewall constructions of A, B, and C flutes and samples of double-wall and triple-wall corrugated fiberboard. The results indicated that there was no practical significant difference in the edgewise compressive strength values obtained using the specimens necked down with a router and those obtained using the TAPPI test method, except for one of the waxed flute samples, which showed low strength because of failure at the loading edges.

52. Rotational Creep of Pallet Joint Specimens

Wilkinson, Thomas Lee

USDA Forest Serv. Res. Note FPL-RN-0253; 1986.

The purpose of this study was to determine the effect of continued load on pallet joints. We describe the creep rotation of pallet joint specimens made of two wood species and with two different types of nails. Joints were subjected to three levels of applied moment and allowed to dry while under load. After approximately 5 months, the specimen rotation had increased 8 to 19 times. The creep rotation behavior of the joints as affected by species of deckboard and stringer, type of fastener, and amount of load is described by a mathematical model.

preservation and protection

Durability of Exterior Wood Finishes Depends on Proper Selection and Application

Cassens, Daniel L.; Feist, William C.

Workbench; March-April 1986. (Available from Information Services Division, Kurt F. Wendt Library, College of Engineering, University of Wisconsin-Madison, 215 North Randall Avenue, Madison, WI 53706; \$5.)

This publication discusses how to select the appropriate finish for the many different types of wood products currently used on structures as well as correct application procedures.

Finally, explanation and remedial action will be given for those cases where finishes fail prematurely because of improper matching of the finish and wood product, poor construction practices, or application procedures.

53. Termite Resistance of Wood Treated with Copper (II) Compounds Derived from Tri- and Dialkylamine-Boric Acid Complexes

Chen, George C.; Esenther, Glenn R.; Rowell, Roger M. Forest Prod. J. 36(5): 18-20; 1986.

The objective of this investigation was to evaluate the toxicity to termites and the leaching stability of copper compounds derived from tri- and dioctylamine boric acid complexes for protecting wood against termite attack. Water-insoluble copper N-methyldioctylamine or copper N-dioctylamine and copper borate were precipitated in wood by the reaction of N-methyldioctylamine or N-dioctylamine-boric acid complex with copper sulfate. Wood treated with these copper (II) compounds was resistant to subterranean termite attack in a modified nutritive supplement test. High or complete termite mortality occurred at 0.08 pcf (or 0.2 pct) for unleached, and 0.89 pcf (or 2 pct) for leached blocks. A notable advantage of the copper compounds over conventional wood preservatives was that termites readily acquired toxic doses by slight feeding on the treated wood; thus, unlike wood treated with conventional wood preservatives, these copper treatments might protect nearby untreated wood from termite attack.

54. SEM X-Ray Microanalysis of Tracheid Cell Walls in Southern Yellow Pine Sapwood Treated with Water-Dispersible Pentachlorophenol

DeGroot, Rodney C.; Kuster, Thomas A.

Wood Fiber Sci. 18(1): 58-67; 1986.

Water-based formulations of pentachlorophenol are an appealing alternative to oil-borne formulations. Their effectiveness is still being evaluated. This study was conducted to determine whether levels of water-dispersible pentachlorophenol in tracheid cell walls increase in proportion to increases in gross retention. Proportionate increases occurred in the S₃ layer between gross retentions of 0.18 and 0.84 pcf (2.9 and 13.4 kg/m³). Increases of pentachlorophenol in the compound middle lamella at cell corners or in the S₂ were not proportional to increases in gross retention above 0.43 pcf (6.9 kg/m³). More pentachlorophenol was detected in the earlywood than in the latewood at all retentions. The P/B ratios for pentachlorophenol in earlywood, but not in latewood, are proportional to gross retention.

55. Durability of Preservative-Treated Wood Utility Poles in Guam

DeGroot, Rodney C.; Lauret, Thomas H.

USDA Forest Serv. Res. Pap. FPL 472; 1986.

Pressure-treated wood utility poles in Guam were inspected to evaluate efficiency of preservative standards. Formosan termites (*Coptotermes formosanus Shiraki*) can destroy the untreated heartwood of Douglas-fir poles treated with creosote, pentachlorophenol, and chromated copper arsenate (CCA). Where Formosan termites are a hazard, a supplemental soil treatment for termite control should be used around Douglas-fir poles pressure treated with creosote or pentachlorophenol. Where Formosan termites are a serious hazard, the utilization of CCA-treated Douglas-fir utility poles should be questioned. Pressure treatments with ammoniacal copper arsenate (ACA) seem to be effective in protecting heartwood of treated Douglas-fir poles from attack by Formosan termites, but additional documentation is needed to determine the full potential of that treatment. Early attack by soft-rot fungi and by termites were detected on some pentachlorophenol-treated southern pine poles in Guam.

Painting and Finishing Wood for Use Outdoors (Part I)

Painting and Finishing Wood for Use Outdoors (Part II)

Feist, William C.

Am. Paint Coatings J. 70(8); September 9, 1985.

Am. Paint Coatings J. 70(9); September 16, 1985.

(Available from Information Services Division, Kurt F. Wendt Library, College of Engineering, University of Wisconsin-Madison, 215 North Randall Avenue, Madison, WI 53706; \$5.)

The primary function of any wood finish (paint, varnish, wax, stain, oil, etc.) is to protect the wood surface, help maintain appearance, and provide cleanability. Unfinished wood can be used both outdoors and indoors without further protection. Wood surfaces exposed to the weather without any finish change color, are roughened by photodegradation and surface checking, and erode slowly. Wood surfaces exposed indoors may change color and accumulate dirt and grease if left unprotected without some finish. (This report has been published in two parts.)

56. Protection of Wood Surfaces Against Photooxidation

Hon, David N.-S.; Chang, Shang-Tzen; Feist, William C.
J. Applied Polymer Sci. 30: 1429-1448; 1985.

Protection of wood surfaces against photoinduced oxidative degradation can be achieved by using effective coating agents. Several penetrating chemical agents, such as triol-G 400, PEG-G 400, and 1-octadecanol, were shown to provide good protection for wood surfaces against discoloration during ultraviolet irradiation. In addition, wood surfaces coated with clear film-forming finishes, such as homo- and copolymers of 2-hydroxy-4 (3-methacryloxy-2-hydroxypropoxy) benzophenone, exhibited outstanding performance into inhibiting discoloration and surface deterioration. Infrared and ultraviolet absorption spectra and scanning electron microscopy studies revealed that the clear polymeric coatings containing an internal UV absorber were very stable and resistant to photooxidation. Possible chemistry and mechanisms of protection of wood surfaces provided by these polymeric coating systems are discussed.

57. Sensitivity of Some Wood Stain and Mold Fungi to an Inhibitor of Chitin Synthesis

Johnson, Bruce R.
Forest Prod. J. 36(3): 54-56; 1986.

Because chitin synthesis occurs only in lower life forms, its inhibition holds promise as a target-specific approach to pest control with minimal effect on nontarget organisms. Wood stain and mold fungi have chitinous hyphal walls but in this study their sensitivity to the highly specific chitin inhibitor, polyoxin, was low. Seven of eight species exposed to polyoxin showed less spore germination and slower hyphal growth but only at rather high polyoxin concentrations. Polyoxin is not a good candidate for protection of wood against stain and mold fungi.

58. Role of Density in the Erosion of Wood During Weathering

Sell, Jürgen; Feist, William C.
Forest Prod. J. 36(3): 57-60; 1986.

Samples from 12 hardwoods and 6 softwoods were artificially weathered. The rate of surface erosion was measured with a light microscope at exposure intervals of 600 hours. The results showed that the rate of erosion per unit time depends predominantly on the wood density and thus on the wood cell wall thickness. The relationship is approximately linear within a density range of 0.3 to 1.0 g/cm³.

59. U.S. and European Finishes for Weather-Exposed Wood—A Comparison

Sell, Jürgen; Feist, William C.
Forest Prod. J. 36(4): 37-41; 1986.

This paper describes different types of wood finishes and compares their use on wood used outdoors in the United States and Western Europe. The primary objective was to provide a mutual exchange of information and to show comparisons. Apart from different traditions in using wood as an outdoor building material, there are interesting differences in the wood finishes used for protective and decorative purposes.

Unterschiede der Oberflächenbehandlung von Holzaussenbauteilen in den USA und in Westeuropa (Treatment of Differences in the Surface Treatment of Exterior Wood Siding in the USA and Western Europe)

Sell, Jürgen; Feist, William C.
Holz-Zentralblatt, Stuttgart Nr. 40/41. (Available from Information Services Division, Kurt F. Wendt Library, College of Engineering, University of Wisconsin-Madison, 215 North Randall Avenue, Madison, WI 53706; \$5.)

This paper describes different types of wood finishes and compares their use on wood used outdoors in the United States and Western Europe. The primary objective was to provide a mutual exchange of information and to show comparisons. Apart from different traditions in using wood as an outdoor building material, there are interesting differences in the wood finishes used for protective and decorative purposes. This paper is printed in German.

Verwitterung von CKB-Getranktem Holz Bei Kunstlicher Wetterbeanspruchung (Weathering Behavior of Chromium-Copper-Boron (CCB)-Treated Wood)

Sell, J.; Feist, W. C.
Holz als Roh- und Werkstoff. 43(12); 1985. (Available from Information Services Division, Kurt F. Wendt Library, College of Engineering, University of Wisconsin-Madison, 215 North Randall Avenue, Madison, WI 53706; \$5.)

This report covers weathering, especially erosion of CCB-treated white fir, and improvement of the durability of a semitransparent surface finish by the CCB-treatment. This paper is printed in German.

processing

60. Comparison of Drying Methods for Paper Birch SDR Flitches and Studs

Larson, Timothy D.; Erickson, Robert W.; Boone, R. Sidney
USDA Forest Serv. Res. Pap. FPL 465; 1986.

Several drying methods were evaluated for use with Saw-Dry-Rip (SDR) paper birch flitches and studs, including high- ($\geq 212^{\circ}\text{F}$) and conventional- ($\leq 180^{\circ}\text{F}$) temperature schedules, dehumidification drying and air drying. The major problem encountered in drying by any of these methods was the presence of darkwood near the pith, which is more impermeable and therefore slower to dry than whitewood and which had a propensity to check, collapse, and honeycomb. The shortest drying time (3 days) and best uniformity of moisture content between darkwood and whitewood were obtained using a high-temperature schedule with an early period of continuous venting. Dehumidification drying of 7/4 flitches to an average moisture content of 10 to 12 percent required about 18 days, and air drying of 7/4 flitches to less than 20 percent moisture content in northeastern Minnesota required 6 months of good air-drying conditions. Fifteen to sixteen days were needed for conventional-temperature schedules to dry 7/4 flitches to 8 to 10 percent moisture content. Thickness shrinkage of flitches dried to 10 percent moisture content was 8 to 9 percent.

61. Sawmill Simulation and the Best Opening Face System: A User's Guide

Lewis, David W.
USDA Forest Serv. Gen. Tech. Rep. FPL-48; 1985.

Computer sawmill simulation models are being used to increase lumber yield and improve management control. Although most managers and technical people in the sawmill industry are aware of the existence of these models, many do not realize their full potential. Attempts to gain more information about sawing models, whether for a better understanding or wanting to use and/or modify a particular model, have frequently been frustrated, because the information has been either lacking or widely scattered. This report consolidates much of the information on sawmill simulation models for those interested.

62. Best Opening Face System for Sweeypy, Eccentric Logs: A User's Guide

Lewis, David W.
USDA Forest Serv. Gen. Tech. Rep. FPL-49; 1985.

Log breakdown simulation models are used by many managers and technical people in the sawmill industry to increase lumber yield and improve management control. This paper discusses a history of log breakdown models, describes applications of the modified BOF, details the modifications made and provides information on how to use the new features.

63. Solar Energy for Wood Drying Using Direct or Indirect Collection With Supplemental Heating: A Computer Analysis

Tschernitz, J. L.

USDA Forest Serv. Res. Pap. FPL-RP-477; 1986.

This paper reports the results of a theoretical computer analysis of many factors in the application of solar energy to the drying of wood. The analysis is restricted to the cases of direct and indirect solar collection with supplemental energy available for direct-fire gas heating. No one design or method of construction is prescribed for this analysis. Instead, the effects on kiln (dryer) efficiency of various thermal properties of the solar collector surfaces and kiln walls are analyzed. Although the computer program is not presented in this report, figures and tables identified with various geographic locations within the United States show energy demand and fuel savings for typical conditions of wood drying. The results are organized to show the effect of these design parameters on the suitability of solar drying for various locations, seasons, and dryer sizes. For any one dryer size and location the "efficiency" of supplemental solar drying is expressed as a percent fuel savings, based upon the net energy (total energy minus electric fan power) consumed by a drying unit operating as a conventional drying system.

pulp and paper

64. Wet Pressing Webs of Higher-Yield Kraft Pulp for Improved Strength

Caulfield, Daniel F.; Young, Teresa L.; Wegner, Theodore H. Tappi J. 69(4): 115-119; 1986.

Guidelines are provided for the modification of wet pressing to compensate for strength losses resulting from use of higher-yield pulps. In this study, for webs of equal freeness and moisture content, the higher-yield pulps resulted in sheets of lower density and strength after wet pressing. A web of a higher-yield pulp (60 pct) can be wet pressed to achieve burst and tensile strength values equivalent to those of a low-yield pulp (51 pct). However, higher sheet density is needed with the higher-yield pulp, which requires a longer nip residence time and/or higher press pressure. When higher-yield pulps are refined to low freeness in order to compensate for strength loss, longer nip residence times may be necessary regardless of press nip pressure. But for higher-yield and high-freeness pulp webs, where dewatering behavior is pressure limited, increasing press nip pressure is the most effective means of compensating for the sheet strength loss accompanying the use of higher-yield pulps.

65. Light-Induced Bleaching of High-Yield Pulps. Part I. Sensitized Bleaching of Pulp Sheets

Green, Jesse D.

J. Wood Chem. Technol. 6(1): 45-71; 1986.

Bleached high-yield pulps undergo a much higher rate of light-induced brightness reversion than their chemical counterparts. This tendency to discolor is one of the main factors limiting the application of high-yield pulps to short-term products such as newsprint, tissue, toweling, and foodboard.

This study was conducted to determine whether the light absorption responsible for aging could be utilized to activate and subsequently destroy the chromophores in high-yield pulps. This would permit production of a bleached pulp.

66. Press Drying Recycled Fiber for Use in Paperboard

Horn, Richard A.; Bormett, David W.

Tappi J. 68(12): 78-83; 1985.

This study determined (a) the effect of press drying on softwood and hardwood recycled fibers, (b) the acceptability of linerboard and medium made from 100 percent recycled fiber using our press dryer pilot machine, and (c) the properties of combined board and corrugated containers made from press-dried recycled fiber. Press drying effectively increased those sheet properties dependent upon fiber bonding, but results indicate that reclaimed fiber must be lightly refined if maximum strength is to be achieved. Press drying had a beneficial effect on short-column compression, especially at high humidity, and effectively eliminated scoreline fracturing. Top-to-bottom compressive strength of containers made from press-dried recycled components was equal to or higher than that of containers made from conventionally dried components made of virgin fiber. Impact failure height, while approximately 15 percent lower for press-dried containers, was satisfactory for today's shipping environment.

Mechanisms by Which White Water System Contaminants Affect the Strength of Paper Produced From Secondary Fiber

Springer, Allan M.; Dullforce, Jon P.; Wegner, T. H. Tappi J. 69(4): 106-110; 1986. (Available from Allan M. Springer, Paper and Engineering Department, 109 Kreger Hall, Miami University, Oxford, OH 45056. No charge.)

Recycling of process water within paper mills has led to a buildup of inorganic and organic contaminants in white water systems. These materials have been shown to cause reduced sheet strength. We have developed a way to determine the mechanisms by which contaminants reduce sheet strength. Specifically, we determine the mechanisms by which iron (ferric chloride), kraft lignin, and defoamer reduce strength of sheets produced from a secondary fiber furnish. We use (1) apparent sheet density as an indicator of interfiber bonded area, (2) Scott internal bond strength divided by apparent sheet density as an indicator of interfiber bond strength per unit area, (3) zero span tensile index as an indicator of fiber strength, and (4) formation tester values to reflect changes in sheet formation.

67. Use of Calcium Sulfite and Air to Bleach a Delignified Aspen Kraft Pulp

Springer, Edward L.; McSweeney, James D. Tappi J. 69(4): 129-130; 1986.

A low lignin aspen kraft pulp has been bleached by slowly metering an aqueous slurry of calcium sulfite into a vigorously aerated suspension of the pulp in water containing a catalytic amount of cupric ion. This system or some improvement on it may prove to be an economic, efficient, chlorine-free bleaching system.

timber requirements and economics

A Model for International Trade in Pulp and Paper

Buongiorno, Joseph

TIMS Studies in the Management Sciences. 21: 41-54; 1986. (Available from Joseph Buongiorno, University of Wisconsin, School of Forestry, 120 Russell Laboratories, Madison, WI 53706. No charge.)

This paper outlines the mathematical structure of a world model of the pulp and paper industry. The model is designed to provide long-term forecasts of supply, demand, trade, and prices of raw materials, and of intermediate and finished products in the sector, based on the behavior of competitive markets. Supply and demand are distinguished by geographical regions. Raw-materials supply is represented by price-responsive supply functions. Manufacturing is modeled by a linear programming structure. Demand for various end products is a function of price, with income as a main shifter. All prices and quantities relating strictly to the pulp and paper sectors are endogenous. Econometric results regarding the magnitude of income and price elasticities of world demand for paper and paperboard are presented.

Productivity Growth in the Paper and Paperboard Industries: A Variable Cost Function Approach

De Borger, Bruno; Buongiorno, Joseph

Canadian J. Forest Res. 15(6): 1013-1020; 1985.

(Available from Joseph Buongiorno, University of Wisconsin, School of Forestry, 120 Russell Laboratories, Madison, WI 53706. No charge.)

This study develops indices of productivity growth for the paper and paperboard industries in the United States. Accurate productivity measures are necessary to evaluate the performance of industries over time. They are also useful to compare different industries within and outside the forestry sector. Moreover, good productivity growth values are needed to guide investment decisions. They are also an essential input in labor contract negotiations.

68. The Economic Impact of Timber Utilization Research

Haygreen, John; Gregersen, Hans; Holland, Irv; Stone, Robert
Forest Prod. J. 36(2): 12-20; 1986.

There is much discussion today of the expenditure of public funds for research. In the Resource Planning Act and other planning processes, better means are needed to evaluate the benefits of timber utilization research. Without such information, the advocates of utilization research are at a disadvantage when competing for scarce public funding resources. This study presents one means for analyzing the benefits of forest products research by determining its impact on softwood timber utilization. Seven groups of technologies were analyzed, including lumber production and use, panel products production, and pulp and paper production. Results of this analysis indicate that expenditures on timber utilization research have been well justified. In fact, the benefits from the seven technologies analyzed justify the expenditure for all utilization and timber management research.

69. The Forest Products Laboratory Wood Products Production Index

Howard, James L.; Stone, Robert N.; Skog, Kenneth, E.
USDA Forest Serv. Res. Pap. FPL 473; 1986.

This study presents a single measure of total wood products production, called the Forest Products Laboratory (FPL) Wood Products Production Index. This measure is simple and useful in tracking both volume and value of forest products production. To show the behavior of the index it is compared to several Federal Reserve Board indices of industrial production using graphs and a log-log model: $\log(FPL_t) = B_0 + B_1 \log(IP_t)$.

70. New Potential for Increased Use of Hardwoods in Kraft Linerboard Production

Ince, Peter J.
Forest Prod. J. 36(2): 32-36; 1986.

This report discusses the current situation in regard to use of hardwood in kraft linerboard, technical constraints and possibilities, financial incentives for greater use of hardwood, possible economic consequences and implications for timber management.

71. Wood Products Used by U.S. Furniture, Fixtures and Architectural Woodwork Manufacturers

McKeever, David B.
Furniture Desi. Manuf. 57(13): 10-18; 1985.

United States furniture and fixtures manufacturers consumed 628 million cubic feet of wood in 1982, 14 percent below consumption in 1977. A 50 percent reduction in new housing starts between 1977 and 1982 adversely affected furniture and fixtures consumption, causing industry shipments, and wood consumption to drop.

Residential Fuelwood Use in the United States: 1980-81

Skog, Kenneth E.; Watterson, Irene A.

Resour. Bull. WO-3. Washington, DC: U.S. Department of Agriculture, Forest Service; 1986. 42 p. (Available from USDA Forest Service, P.O. Box 2417, Washington, DC 20013. No charge.)

In 1981 the USDA Forest Service, Forest Products Laboratory, in cooperation with the Wisconsin Survey Research Laboratory, conducted a nationwide telephone survey to determine the amount of residential woodburning and its impact on home heating and forestry. This report provides survey results and analysis of the demand for fuelwood and sources of fuelwood supply. The report first presents a discussion of study methods, followed by sections about fuelwood consumption and acquisition. Second, it compares our results and results from surveys by the U.S. Department of Energy and the 1980 Census of Population and Housing. The report concludes with a glossary, a section on literature cited, and an appendix of data tables.

Timber Supply Information: Meeting Industrial Needs

Stone, Robert N.

In: Ellefson, Paul V.; Lewis, Bernard J.; Skok, Richard, eds. Industry as a Force in Economic Development: Options for Minnesota's Future; Proceedings of the Governor's Conference on Forestry; 1984 December; St. Paul, MN. St. Paul, MN: University of Minnesota, Agricultural Experiment Station/College of Forestry; 1985: 18-20. (Entire proceedings available: College of Forestry, 110 Green Hall, 1530 North Cleveland Ave., University of Minnesota, St. Paul, MN 55108.)

Statistics gathered during the 1962 and 1977 forest surveys reveal substantial change in Minnesota's forests; the overall changes in volume and area are huge if viewed in percentage terms. Hidden within these overall trends are some equally interesting but complex and dynamic changes that are specific to an expanding forest composed of dozens of forest species. The data reflect, for example, waves of tree age classes and volumes that are shifting the basic character of the timber resource. Between the two forest surveys, timber inventories increased from 7 to 10 cords per acre, a change which has clear implications for the cost of harvesting wood. Such changes are occurring in Minnesota and across the Lake States.

special item

Finishing Wood Exteriors: Selection, Application, and Maintenance

Cassens, Daniel L.; Feist, William C.
Agric. Handb. No. 647. Washington, DC: U.S. Department of Agriculture, Forest Service; 1986. 56 p. (Available from Superintendent of Documents, U.S. Government Printing Office, 710 N. Capitol Street, Washington, DC 20402; \$3.25; 001-000-04450-8.)

This new USDA handbook brings together the results of more than 60 years of continuing research on exterior wood finishing.

The new publication details the basic characteristics of wood and reconstituted wood-based products. Particularly, it focuses on the finishing and performance characteristics of different woods, manufacturing and construction practices that affect surfaces to be finished, and the ways that various finishes interact with these characteristics and practices.

The Handbook also outlines different types of finishes that can be used on wood outdoors, their compatibility with different wood products, and proper application and reapplication procedures. Resistance of the finish and wood product to weathering is also discussed. Finally, steps are given on how to diagnose and correct finish failures.

Following the suggestions in this extensive publication will help insure maximum service life from your wood product and finish combination while maintaining desired aesthetic qualities.



Semitransparent penetrating stains give a "natural" or "rustic" wood appearance. They are available from commercial sources in a variety of colors.



Technological improvements in finishes combined with proper application techniques enable some paint systems to last as long as 10 years.

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